1.1-2.4; $P < .0001$). Independent predictors of stroke included CAS (OR 1.6; 95% CI,1.3-2.0; $P < .0001$) and symptomatic disease (OR, 2.4; 95% CI, 1.9-3.0; $P < .0001$). Among subgroups according to neurologic presentation, regression showed that CAS significantly increased the odds of stroke in asymptomatic patients (OR, 1.6; 95% CI, 1.2-2.0; $P = .0003$). Among symptomatic patients, CAS increased the odds of in-hospital death (OR, 3.0; 95% CI, 1.7-5.1; $P < .0001$) and trended towards significance for stroke (OR, 1.7; 95% CI, 1.0-2.8; $P = .0569$); odds of stroke were lower in 2006 than in 2005 (OR, 0.6; 95% CI, 0.4-0.9; $P = .009$; Table, Fig).

Conclusions: Despite a 66% increase in CAS in 2006, no significant improvement in mortality or stroke was observed in 2005. These rates remained higher than CEA regardless of patient presentation. Resource utilization as measured by charges and discharge disposition also favored CEA.

Table. Univariate analysis of postprocedural mortality and stroke

Patients	*Year*	*Crude in-hospital mortality, %*			*Crude postprocedural stroke, %*		
		CAS	*CEA*	P *(CAS vs CEA)*	*CAS*	*CEA*	P *(CAS vs CEA)*
All patients	2005-06	0.95	0.45	.0045	1.6	0.95	.0001
	2005	0.93	0.45	.0391	1.8	1.0	.0081
	2006	0.95	0.45	.0121	1.5	0.89	.0051
P (2005 vs 2006)		NS	NS	. . .	NS	NS	. . .
Asymptomatic	2005-06	0.66	0.38	NS	1.4	0.86	.0005
	2005	0.57	0.38	NS	1.5	0.88	.0129
	2006	0.71	0.39	NS	1.3	0.83	.0176
P (2005 vs 2006}		NS	NS	. . .	NS	NS	. . .
Symptomatic	2005-06	4.0	1.2	.0018	3.6	2.0	.0493
	2005	4.6	1.4	.0235	4.1	2.5	NS
	2006	3.5	1.0	.0293	3.2	1.5	NS
P (2005 vs 2006)		NS	NS	. . .	NS	.0181	. . .

CAS, Carotid angioplasty and stenting; CEA, carotid endarterectomy; NS, not significant.

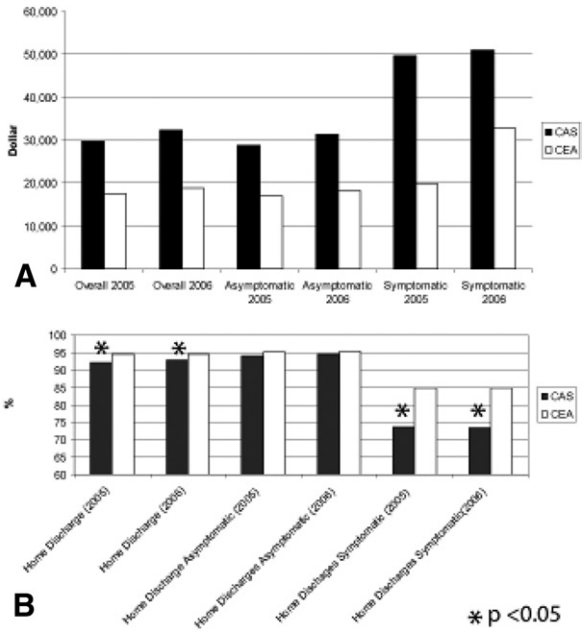

Fig. A, Median hospital charges. **B,** Home discharges after carotid revascularization. *CAS,* Carotid angioplasty and stenting; *CEA,* carotid endarterectomy.

Long-Term Outcome of Carotid Endarterectomy with Bovine Pericardial Patch Closure: A Comparison to Dacron Patch and Primary Closure

Karen J. Ho,* and Matthew T. Menard, From Brigham and Women's Hospital, *Boston, Mass*

Objectives: Bovine pericardial patches (BPP) are increasingly used during femoral and carotid endarterectomies (CEA), and owing to handling and sonographic properties, have become our patch material of choice in recent years. However, the long-term performance of this material compared with other CEA closure strategies remains poorly defined. We sought to determine how infection and bleeding complications after CEA performed with BPP compared with CEA performed with Dacron patches or primary closure (PC).

Methods: All consecutive CEA performed between January 1, 1996, and December 31, 2008, at a single institution were entered real-time into a relational database.

Results: During the 12-year study period, 1331 CEAs were performed (Table). Mean follow-up was 1412 days (median, 1147 days). There were no statistically significant differences in the rates of postoperative wound infection, hematoma, stroke, or 30-day mortality in the three groups. Five-year patency was significantly improved with BPP and Dacron patches compared with PC. Five-year survival was also enhanced with BPP compared with Dacron patches and PC.

Conclusions: In this nonconcurrent cohort study, which represents the largest reported experience with BPP during CEA to date, the rate of postoperative bleeding and infection complications with BPP was similar to that with Dacron patching and PC. Beyond equivalent clinical performance, our data suggest BPP is associated with increased long-term survival.

Table. Comparison of patch closure for carotid endarterectomy

Outcome	*BPP (n = 457)*	*Dacron (n = 642)*	*PC (n = 216)*	P
Infection, No. (%)	3 (0.6)	2 (0.3)	0 (0)	NS
Hematoma, No. (%)	16 (3.5)	21 (3.3)	5 (2.3)	NS
Stroke, No. (%)	6 (1.3)	14 (2.2)	1 (0.5)	NS
30-day mortality, No. (%)	6 (1.3)	5 (0.8)	0 (0)	NS
5-year patency, %	98.9 ± 0.6	98.0 ± 0.6	94.8 ± 1.6	
BPP vs PC				.005
Dacron vs PC				.031
5-year survival, %	77.9 ± 3.6	69.8 ± 2.1	66.9 ± 3.5	
BPP vs Dacron				.026
BPP vs PC				.014

Continuous data are mean ± standard deviation
BPP, Bovine pericardial patches; *PC,* primary closure.

Stroke and Death after Carotid Endarterectomy and Carotid Artery Stenting with and without Coronary Artery Bypass

Kristina A. Giles,* Frank B. Pomposelli, Allen D. Hamdan, Marc Wyers, and Marc L. Schermerhorn, From Beth Israel Deaconess Medical Center. *Boston, Mass*

Objectives: By Centers for Medicare and Medicaid Services (CMS), carotid artery stenting (CAS) patients are high surgical risk. We evaluated mortality and stroke after CEA and CAS combined with and without coronary artery bypass grafting/valve surgery (CABG/V) and adjusted for medical high-risk criteria.

Methods: The Nationwide Inpatient Sample (2004-2006) was queried by *International Classification of Diseases, 9th Revision,* codes for CEA and CAS with diagnosis of carotid artery stenosis. CABG/V procedures were also identified. Symptom status was defined by history of stroke, transient ischemic attack (TIA), and/or amaurosis fugax. Postoperative stroke was defined by coding for postoperative complications (997.02).

Results: We identified 367,255 CEA (90%) and 40,404 CAS (10%). CABG/V was performed more commonly with CEA than CAS (2.9% vs 1.0%, $P < .001$). Demographics and comorbidities are summarized in Table I. Patients undergoing CAS alone or CAS with CABG/V were more likely symptomatic (13.6% vs 13.3%) than those undergoing CEA alone or CEA with CABG/V (9.6% vs 6.9%; $P < .001$ vs $P < .05$). Mortality was 0.6% for carotid intervention alone and 4.1% for tandem CABG/V ($P < .001$). Stroke occurred in 1.0% of carotid procedures alone and in 3.4% of CABG/V. Stroke or death was 1.4% for CEA vs 3.6% for CAS alone and 7.0% for CEA vs 11.4% for CAS with CABG/V. Multivariate predictors of stroke or death included age, symptom status, congestive heart failure,

chronic renal failure, chronic obstructive pulmonary disease, CABG/V, and CAS (Table II). CAS carried a 2.5-fold increased risk of stroke or death vs CEA.

Conclusions: CAS from 2004 to 2006 had a higher risk of stroke and death than CEA with and without CABG/V, even after adjustment for CMS high-risk criteria. Further risk-adjusted prospective and randomized analyses are needed before broad expansion of CAS.

Table I. Demographics and comorbidities

Variables	*CEA*	*CAS*	P[a]
Total patients, No (%)	367,255 (90.1)	40,404 (9.9)	
With CABG/V	10,719 (2.9)	399 (1.0)	<.001
Without CABG/V	348,414 (97.1)	38,166 (99.0)	<.001
Age >80 y, %	16.8	17.5	.08
Female, %	42.6	39.8	<.001
CHF, %	6.7	10.1	<.001
Renal failure, %	4.0	6.8	<.001
COPD, %	21.5	18.1	<.001
Symptomatic, %	9.6	13.6	<.001
With CABG/valve	6.9	13.3	<.05
Without CABG/V	9.5	13.5	<.001
Stroke or death, %	1.4	3.6	<.001
With CABG/V	7.0%	11.4	.13
Without CABG/V	1.3%	3.5	<.001
Mortality	0.6%	1.7	<.001
With CABG/V	4.0%	6.4	.30
Without CABG/V	0.4%	1.7	<.001

CABG/V, Coronary artery bypass grafting with valve surgery; *CAS,* carotid artery stenting; *CEA,* carotid endarterectomy; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease.
[a]$P < .05$ is statistically significant.

Table II. Multivariate predictors of stroke or death

Predictor	*OR*	*95% CI*	*P*[a]
Carotid artery stenting	2.5	2.2-2.8	<.001
Symptomatic	7.1	6.3-8.0	<.001
CABG/V (vs no cardiac procedure)	6.8	5.7-8.1	<.001
Congestive heart failure	2.2	1.8-2.5	<.001
Chronic renal failure	1.6	1.3-2.0	<.001
COPD	1.2	1.05-1.4	<.01
Age (by decade)	1.1	1.02-1.14	<.05
Female gender	1.1	1.0-1.2	.19

CABG/V, Coronary artery bypass grafting with valve surgery; *CI* confidence interval; *COPD,* chronic obstructive pulmonary disease; *OR,* odds ratio.
[a]$P < .05$ is statistically significant.

Novel Implantable Vein Graft Contrast Yields Enhanced Outer Wall Definition in Magnetic Resonance Imaging

C. Keith Ozaki,* Dimitrios Mitsouras,* Praveen K. Vemula,* Dia Smiley,* Ming Tao,* Peng Yu,* Christina Campagna,* Weian Zhao,* Robert V. Mulkern,* Jeffrey Karp,* and Frank Rybicki, From Brigham and Women's Hospital. *Boston, Mass*

Introduction: Emerging data support a role for negative wall remodeling in the failure of vascular interventions such as vein grafts, yet clinicians and researchers currently lack the ability to temporally and efficiently interrogate the adventitial surface topography and total vascular wall anatomy in vivo. Our long-term goal is the development of an implantable contrast material immobilized on the vein conduit outer surface ex vivo at the time of operation that will allow high-throughput and spatial resolution vascular wall imaging in vivo longitudinally. We hypothesized that commercially available iron (Fe) magnetic nanoparticles can be covalently immobilized onto the human vein graft wall and subsequently enable delineation of the adventitia with magnetic resonance imaging (MRI).

Methods: Carboxy-modified Fe nanoparticles (30 nm) were activated through *N*-hydroxysuccinimide ester, incubated on human vein adventitia (covalently binds to amines), and thoroughly rinsed. Vein segments were imaged on a 3T MRI system with proton-density, T2*, T1, inversion-recovery contrasts. Histology served as the morphometric standard.

Results: The Fe nanoparticles induced a thin layer of negative contrast that differentiated the adventitia from surrounding saline signal in all MRIs (Fig *A* and *B*), enabling delineation of wall anatomy (*C*); this was not possible in simultaneously imaged unlabeled control veins (*D*). Fe dose/response was also observed (*B*, low [left] to high [right] dose).

Conclusions: Fe can be immobilized (dose-dependent) on human vein for MRI detection, greatly enhancing subsequent delineation of total wall anatomy. This novel imaging approach offers a potentially revolutionary strategy for longitudinal enhancement of vascular biology imaging in vivo.

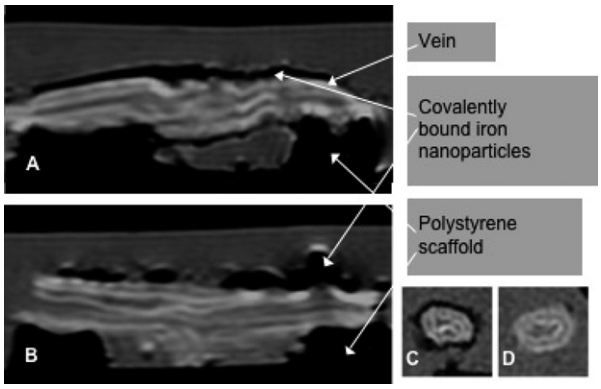

Fig. A, Fe nanoparticles induced a layer of negative contrast in magnetic resonance imaging (MRI) that differentiated the adventitia from surrounding saline. **B,** Fe dose/response from low to high is shown *left* to *right*. MRI showed wall anatomy in **(C)** Fe-labeled vein but (D) not in unlabeled control veins (D).

A Novel Cellular Model of Vein Graft Adaptation

Amanda Feigel,* Akihito Muto,* Tiffany Fancher,* Mariangela Rivera,* Aaron Feinstein*, Susun Kim*, Yuka Kondo*, and Alan Dardik, From Yale University. *New Haven, Conn*

Introduction: Vein graft adaptation (VGA) is characterized by thickening of the vein wall, a complex process involving cell proliferation and migration. We have previously shown that VGA is also characterized by loss of the venous determinant Eph-B4. We developed an in vitro model to study molecular mechanisms that mediate VGA.

Methods: Aortic interposition grafts were examined using vein from wild-type and Eph-B4 heterozygous knockout (Eph-B4-KO) mice. Endothelial cells (EC) were isolated from wild-type and Eph-B4-KO mice. Cell proliferation was directly counted. Quantitative polymerase chain reaction (qPCR) was used to evaluate basal messenger RNA (mRNA) expression. Western blot was used to evaluate protein levels. Under basal and Ephrin-B2/Fc-stimulated conditions, angiogenic tube formation was measured by tube formation assay, cell migration was evaluated using a Boyden chamber, and nitric oxide (NO) production was evaluated fluorometrically.

Results: Vein grafts from Eph-B4-KO mice had 50% increased neointimal thickness vs wild-type vein grafts ($P \leq .01$). Under basal conditions, Eph-B4-KO cells proliferated 41% more slowly than wild-type EC ($P = .029$) and 43% more slowly when stimulated with Ephrin-B2/Fc. Basal levels of Akt were 29% higher, and vascular endothelial growth factor (VEGF) was 28% lower in Eph-B4-KO cells vs wild-type EC. Under direct stimulation, levels of phosphorylated Akt were 31% greater and levels of phosphorylated extracellular signal-regulated kinase 1/2 were 12% greater in Eph-B4-KO cells vs wild-type cells. QPCR confirmed 49% less VEGF-A mRNA expression in Eph-B4-KO cells. Eph-B4-KO cells had 87% greater angiogenic tube formation ($P \leq .001$) and 14% greater NO production ($P = .0092$) under stimulated conditions. Eph-B4-KO cells had 60% reduced cell migration in response to Ephrin-B2/Fc ($P = .005$).

Conclusions: EC isolated from Eph-B4-KO mice is a novel in vitro cellular model of VGA. This model suggests that reduced Eph-B4 expression during VGA may be mediated by upstream signals such as VEGF-A as well as downstream signal pathways such as Akt.

Divergent Systemic and Local Inflammatory Response to Hind Limb Demand Ischemia in Wild-Type and Hypercholesterolemic Mice

Robert S. Crawford,* Hassan Albadawi,* Alessandro Robaldo,* Christopher J. Abularrage,* Hyung-Jin Yoo,* Michael A. Peck,* and Michael T. Watkins, From Massachusetts General Hospital. *Boston, Mass*

Introduction: In patients with peripheral vascular disease, claudication is a frequent symptom related to skeletal muscle demand ischemia. These